Piedad Brox, Iluminada Baturone, and Santiago Sánchez-Solano

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Fuzzy Logic-Based Algorithms for Video De-Interlacing, 2010
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Fuzzy Logic-Based Algorithms for Video De-Interlacing

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Preface

The ‘Fuzzy Logic’ research group of the Microelectronics Institute of Seville is composed of researchers who have been doing research on fuzzy logic since the beginning of the 1990s. Mainly, this research has been focused on the microelectronic design of fuzzy logic-based systems using implementation techniques which range from ASICs to FPGAs and DSPs. Another active line was the development of a CAD environment, named Xfuzzy, to ease such design. Several versions of Xfuzzy have been and are being currently developed by the group. The addressed applications had basically belonged to the control field domain. In this sense, several problems without a linear control solution had been studied thoroughly. Some examples are the navigation control of an autonomous mobile robot and the level control of a dosage system.

The research group tackles a new activity with the work developed in this book: the application of fuzzy logic to video and image processing. We addressed our interest to problems related to pixel interpolation, with the aim of adapting such interpolation to the local features of the images. Our hypothesis was that measures and decisions to solve image interpolation, which traditionally had been done in a crisp way, could better be done in a fuzzy way. Validation of this general hypothesis has been done specifically in the interpolation problem of video de-interlacing. De-interlacing is one of the main tasks in video processing. It is necessary whenever the transmission standard uses an interlaced format but the receiver requires a progressive scanning, as happens to LCDs and plasma displays, projectors, and DVDs. Besides, de-interlacing is usually the first step before applying conversion between two formats, a practice in crescent use due to the proliferation of different video formats.

With the main goal of developing fuzzy logic-based algorithms capable of improving state-of-the-art algorithms for video de-interlacing, the following sub-goals have also been pursued:

- To obtain a simple hierarchical solution which gains efficiency from the combination of its simple constituents (interpolators), being each interpolator specialized in one of the three key image features for de-interlacing: motion, edges,

and possible repetition of areas of fields. Thus, a 'divide-and-conquer' strategy is followed.
- To take inspiration for each interpolator from well-known crisp algorithms so as to make apparent the advantages of using fuzzy processing.
- To apply heuristic knowledge expressed linguistically as the starting point to design the rules of the interpolators, thus exploiting the ability of fuzzy logic to cope with symbolic knowledge.
- To apply a tuning process of the parameters of the rules so as to minimize the error between progressive (ideal) results and de-interlaced results, thus taking advantage of the other side of fuzzy rule bases: its numeric nature.
- To test the performance of the proposed interpolators as well as the final solution with a wide variety of sequences of different formats and origins (video, film, and hybrid).
- To compare our proposal with state-of-the-art algorithms of less, similar, and higher complexity. Not only quantitative evaluations (MSE and PSNR) but also qualitative appreciations will be considered since de-interlaced results will be seen at last by a human.
- To use a computer-aided-design methodology that combines Matlab and its Image Processing to develop image processing algorithms, and Xfuzzy 3 and its tool *xfsl* to tune the parameters of the different fuzzy rule bases proposed.
- To always consider hardware simplicity as a relevant weight when deciding among global (architectural-related) as well as particular (parameter-related) design aspects. These decisions will ease the hardware implementations of the algorithms.

The book is organized in five chapters. In Chapter 1, some basic concepts are explained to completely understand the contribution of the algorithms developed in this research work. The evaluation of how motion is present and how it influences on de-interlacing is studied in Chapter 2. The design options of the proposed fuzzy motion-adaptive de-interlacing algorithm is studied in Chapter 3. A spatial interpolator that adapts the interpolation to the presence of edges in a fuzzy way is developed in Chapter 4. A temporal interpolator that adapts the strategy of the interpolation to possible repetition of areas of fields is presented in Chapter 5. Using both interpolators in the fuzzy motion-adaptive algorithm described in Chapter 3 clearly improves the de-interlaced results.

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